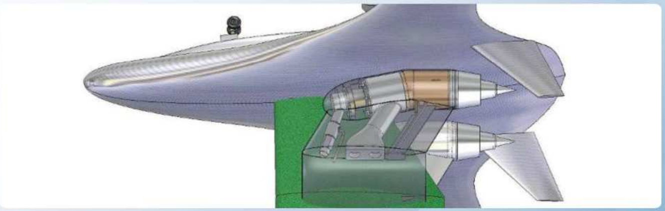
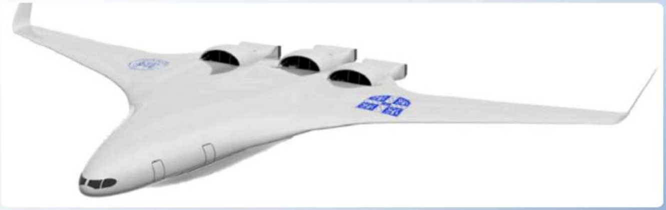
National Aeronautics and Space Administration

NASA's Current Plans for ERA Vehicle Systems Integration

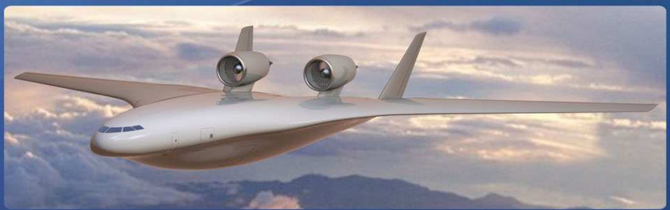
Steve Smith
Project Engineer (Acting)
Vehicle Systems Integration
Sub-project for ERA, NASA





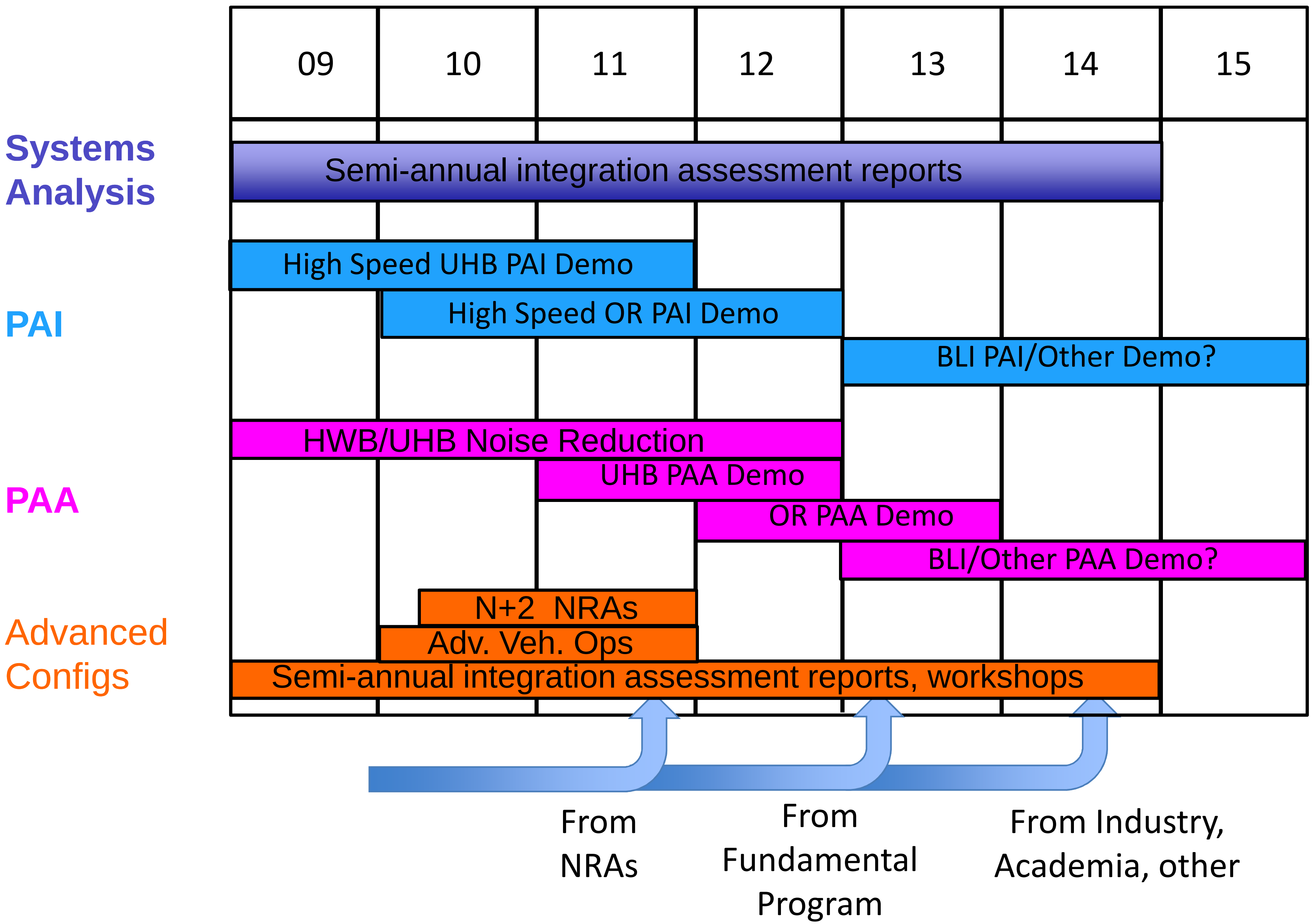






48th AIAA
Aerospace Sciences Meeting
January 4, 2010

Vehicle Systems Integration -- Overview



ERA System Level Metrics and Approach

…. technology for dramatically improving noise, emissions, & performance

CORNERS OF THE TRADE SPACE	N+1 = 2015*** Technology Benefits Relative To a Single Aisle Reference Configuration	N+2 = 2020*** Technology Benefits Relative To a Large Twin Aisle Reference Configuration	N+3 = 2025*** Technology Benefits
Noise (cum below Stage 4)	-32 dB	-42 dB	-71 dB
LTO NO_x Emissions (below CAEP 6)	-60%	-75%	better than -75%
Performance: Aircraft Fuel Burn	-33%**	-40%**	better than -70%
Performance: Field Length	-33%	-50%	exploit metro-plex* concepts

***Technology Readiness Level for key technologies = 4-6

** Additional gains may be possible through operational improvements

* Concepts that enable optimal use of runways at multiple airports within the metropolitan area

ERA Approach

- Focused on N+2 Timeframe – Fuel Burn, Noise, and NO_x System-level Metrics

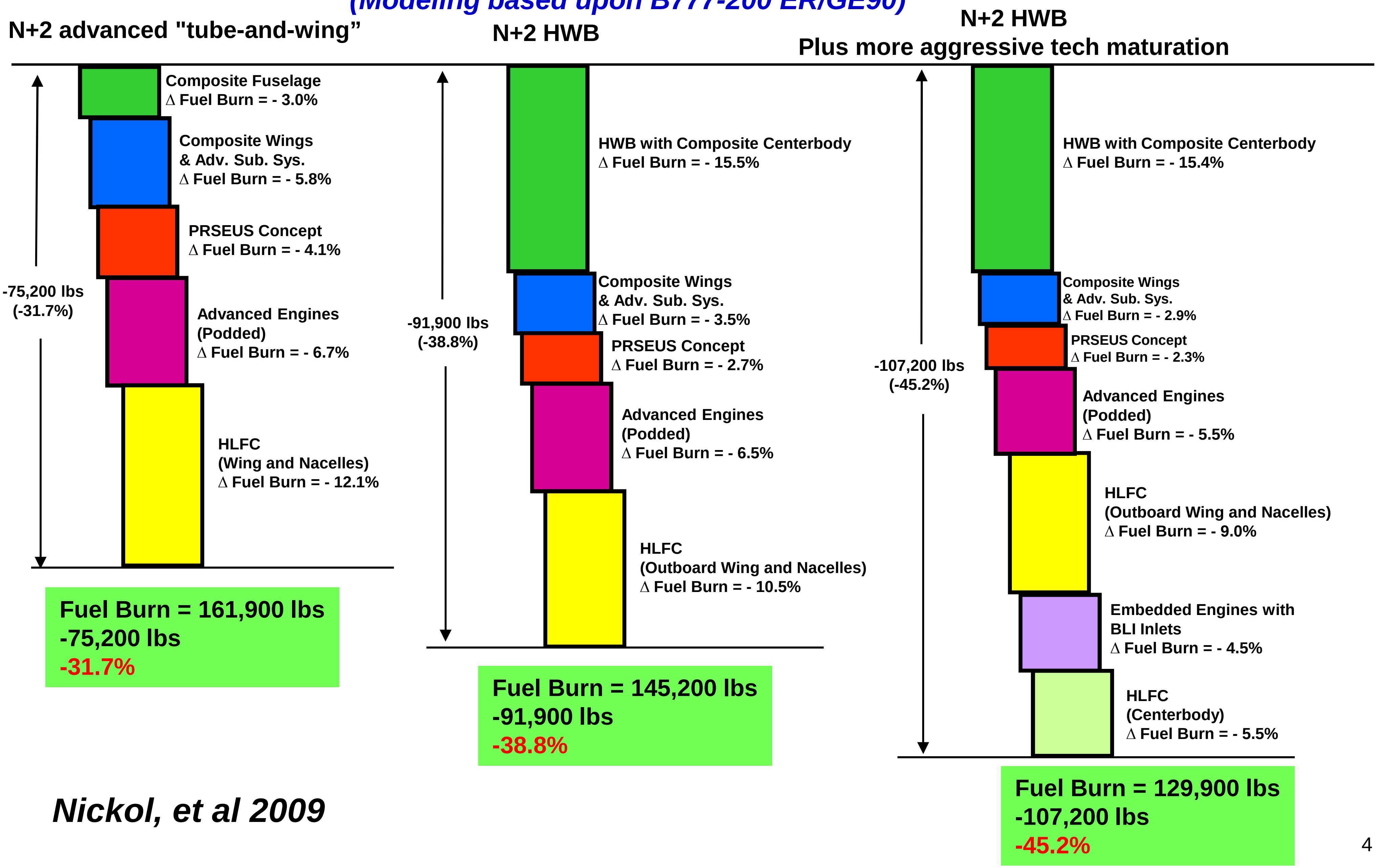
- Focused on Advanced Multi-Discipline Based Concepts and Technologies

- Focused on Highly Integrated Engine/Airframe Configurations for Dramatic Improvements

Potential Reduction in Fuel Consumption

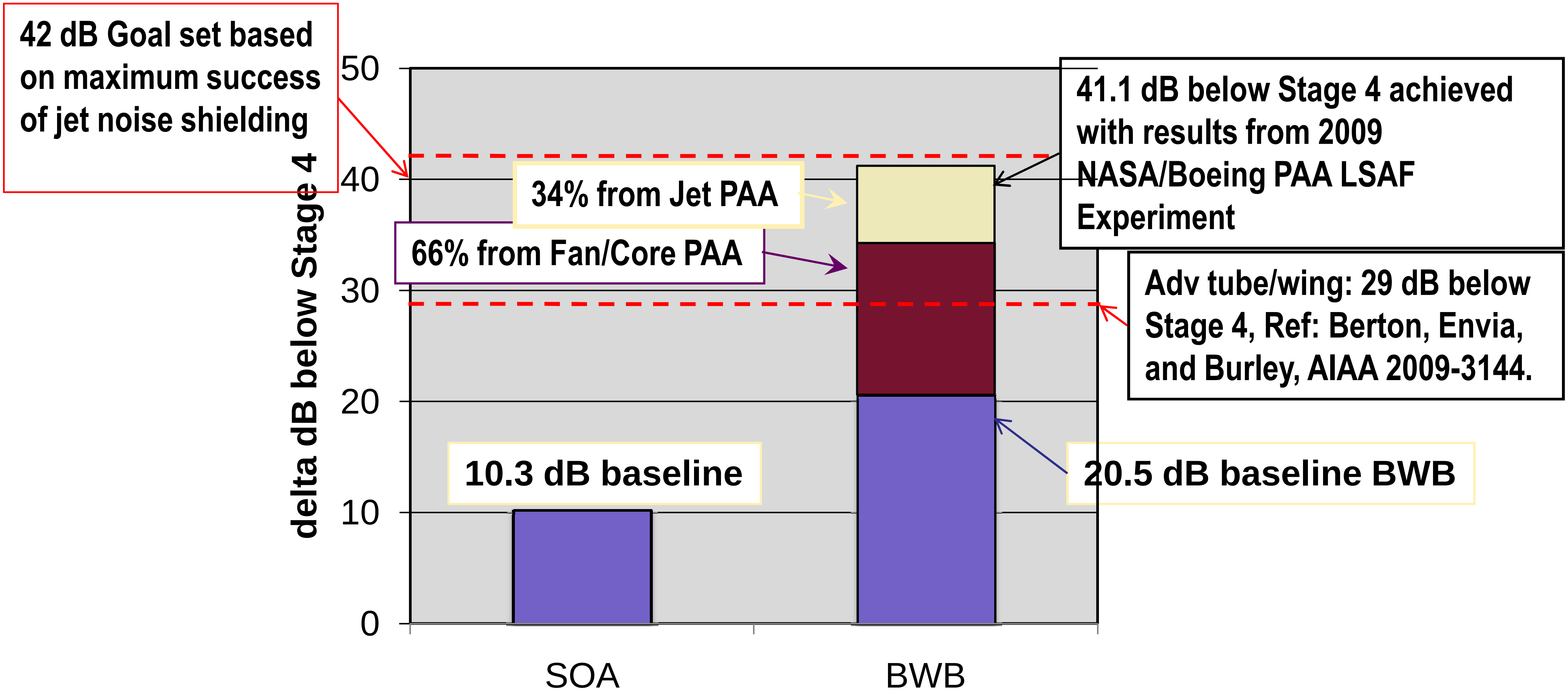
N+2 advanced “tube-and-wing” and Hybrid Wing Body Transport Comparisons

Technology Benefits Relative to Large Twin Aisle
(Modeling based upon B777-200 ER/GE90)



Nickol, et al 2009

N+2 Potential Noise Reduction
2009 Assessment Result : 41.1 dB Cumulative

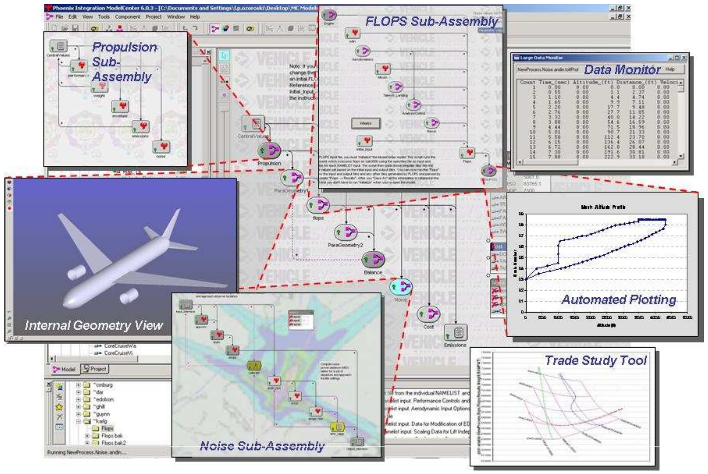


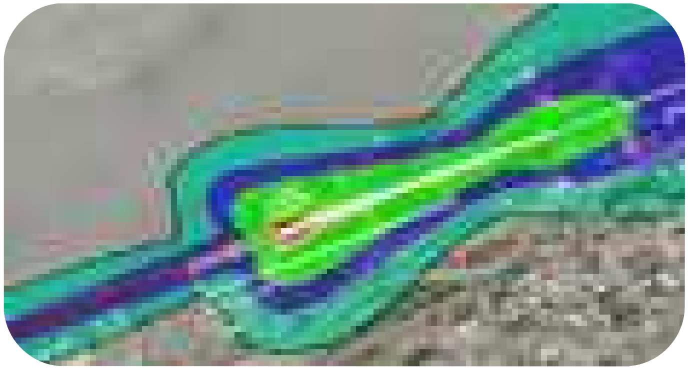
Ref: Thomas, Burley, Czech, and Elkoby. "Progress Toward N+2 Noise Goal: HWB Propulsion Airframe Aeroacoustics (PAA) Boeing/NASA Low Speed Aeroacoustics Facility (LSAF) Experiment and System Noise Assessment." Fundamental Aeronautics Annual Meeting, October 1, 2009.

Systems Analysis - Technical Overview

Energy Efficiency | Noise Reduction

- **Objective**
  - Identify and prioritize potential technologies and configs capable of system level benefits
- **Approach**
  - Conduct technology survey to identify ideas with the potential to reach TRL 6-7 in the 2020 timeframe
  - Perform an ‘Analysis of alternatives’ to prioritize technologies
  - Create a suite of “technology collectors” to estimate system level performance
  - Assess impact of most promising technologies/configurations on ATS (community noise, CO_2 output, LTO NO_x, etc.)
- **Benefit(s)**
  - Provides insight into technology integration and potential synergies at the systems level
  - Provides stakeholders/researchers with quantifiable payoffs and benefits





Systems Analysis - Milestones/Partners

Energy Efficiency | Noise Reduction

Milestones

Annual technology/configuration assessments
Annual assessments of impact of vehicle concepts on ATS

Partnerships

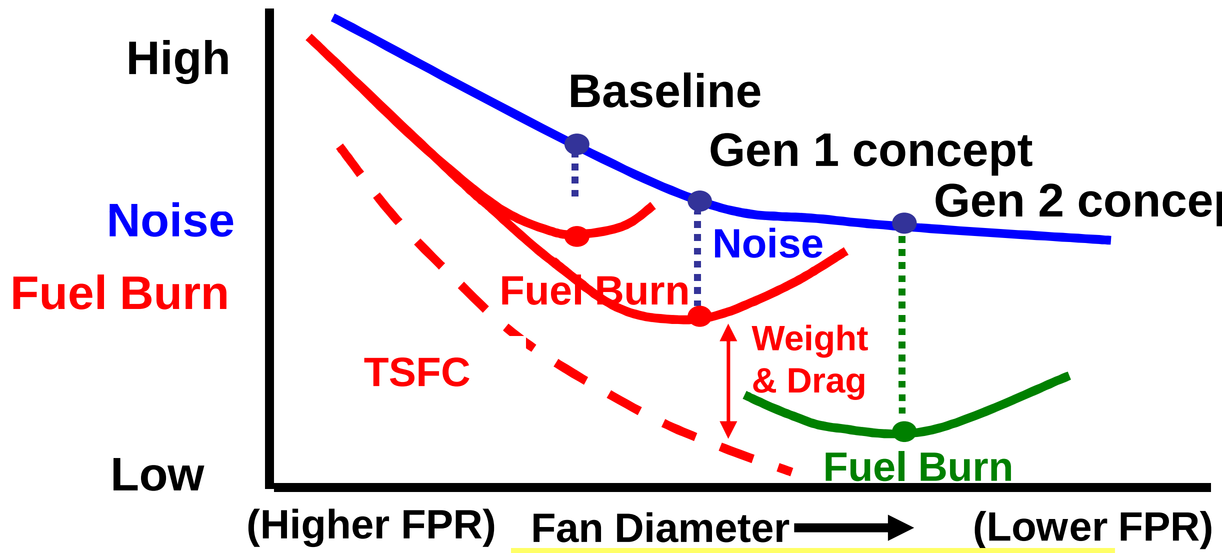
Interagency Agreement LaRC/AFRL supports BWB
Boeing Contracts fund AFRL BWB Options
NRA Cal Poly/Phoenix - MDAO geometry tools
NRA AVID - HWB sys analysis/design tools

Propulsion Airframe Integration - Technical Challenge

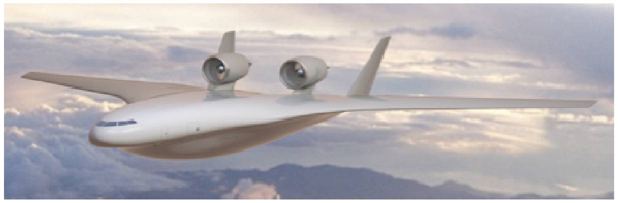
Energy Efficiency

UHB Installation that minimizes or avoids performance penalties

Increased size of system may drive need for alternate configurations



PAI Challenges Increase



- Increasingly large diameters present increasingly difficult installations for conventional low wing configurations, and may require alternate configurations/installations to take advantage of propulsive efficiency

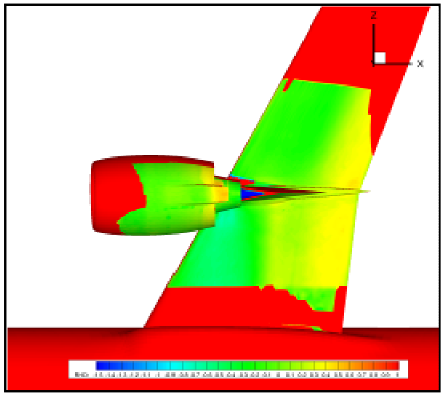
    .... significant vehicle level trade space to explore

Propulsion Airframe Integration - Technical Overview

Energy Efficiency

- **Objective**
  - **Demonstrate efficient integration of advanced propulsor and airframe concepts**
- **Approach**
  - **Explore installed performance trade-offs of alternate engine airframe integrations (e.g. high wing, over-wing-nacelle, boundary layer ingestion)**
  - **Simultaneous wing-nacelle aero shape optimization**
  - **Assess performance benefits thru large-scale powered testing with open rotor and UHB propulsors**
  - **Benefit**
  - **Design tools and enlarged PAI design trade space with new open rotor and UHB propulsors and advanced N+2 airframes (40% fuel burn reduction)**

Powered half-span model test in Ames 11' wind tunnel



Pressure Sensitive Paint results

Propulsion Airframe Integration - Milestones/Partnerships

Energy Efficiency

Milestones

June 2010 UHB Integration Aero Shape Opt
Oct 2010 Open Rotor Experiment Design
Dec 2010 UHB Fan TPS and Semispan model Fab
Dec 2011 UHB Integration Performance Assessment
Oct 2013 Open Rotor Integration Performance Assessment

Partnerships

SAA's - P&W GTF Study, TBD Open Rotor Study Design and Hardware Contracts TPS and Model Fab

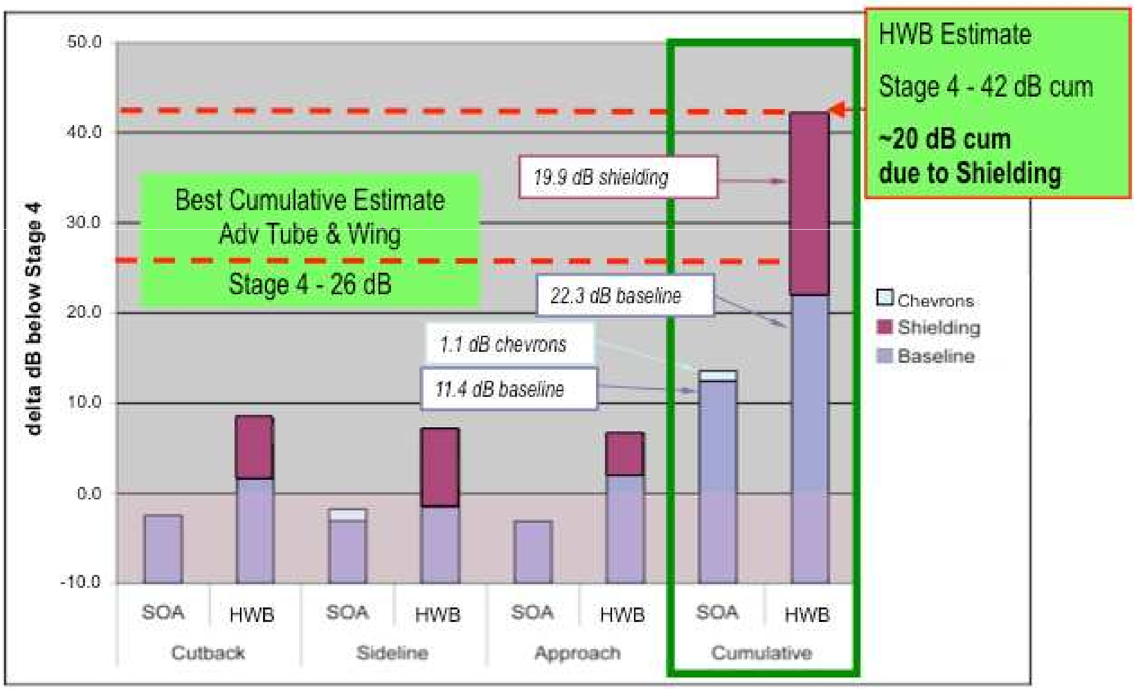
Propulsion Airframe Aeroacoustics - Technical Challenge

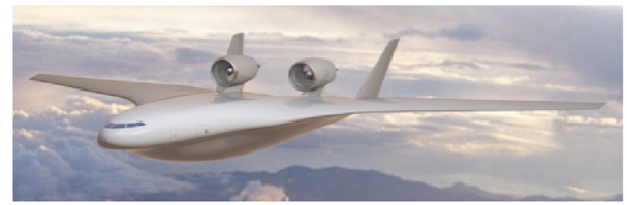
Noise Reduction

Efficient UHB and/or Installation must minimize community noise

Drives the need for alternate configurations that employ advanced propulsors with shielding

Includes estimate of maximum propulsion noise shielding





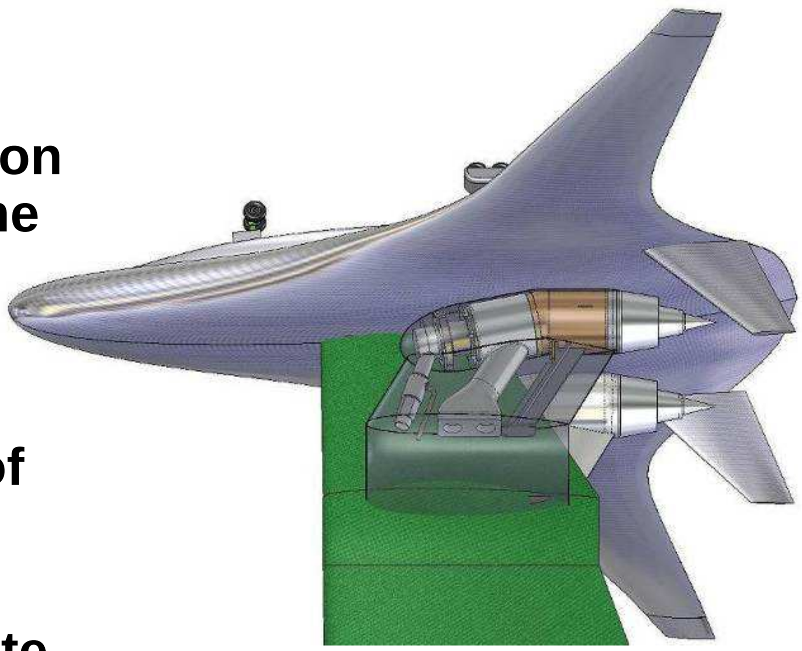
- Increasingly large diameters present
  - increasingly difficult installations for conventional low-wing configurations
  - may require alternate configurations/installations to take advantage of aero-propulsive efficiency AND
  - systems studies indicate airframe shielding required to achieve the desired noise reductions

    …. significant vehicle level trade space to explore

Propulsion Airframe Aeroacoustics - Technical Overview

Noise Reduction

- **Objective**
  - **Demonstrate favorable acoustic interaction between advanced propulsor and airframe concepts**
- **Approach**
  - **Assess airframe shielding benefits thru large-scale powered testing integration of advanced low noise/efficient open rotor and UHB propulsors**
  - **Quantify aeroacoustic benefits of alternate engine airframe integrations (e.g. high wing, engine-over-wing, boundary layer ingestion, etc.)**
- **Benefit**
  - **Enlarged PAA design trade space for new open rotor and UHB propulsors (and integrations) with advanced N+2 airframes (36-42 dB cum reduction to Stage 4)**



Propulsion Airframe Aeroacoustics - Milestones/Parnterships

Noise Reduction

Milestones

Aug 2009 LSAF UHB Shielding Test Complete (HWB/OWN)
Sept 2010 Noise Assm't of LSAF HWB and OWN
Dec 2010 LSAF Open Rotor Test Complete
Dec 2011 Hot Jet Test Technique and 14x22 Acoustic Upgrade
Sept 2012 HWB Shielding/ Noise Red. Validated
Oct 2012 UHB Noise Assm't Test

Partnerships

SAA's Boeing R&T
NRA's Current Boeing/MIT/UCI for HWB development
Contracts TEAMS, CONITS, RECOM III

Advanced Vehicle Concepts - Technical Overview

Noise Reduction | Energy Efficiency

<u>4.4.1 Advanced Vehicles Operation in Airspace</u>

- **Objective**
  - **Understand synergistic coupling between advanced N+2 configurations and their operations within the NAS**
  - **Quantify benefits derived in terms of noise reduction and energy efficiency by making terminal area procedures more efficient while assessing the cost of implementing N+2 technology**
- **Approach**
  - **Contracted studies by industry to examine N+2 technology impacts to flight operations especially pertaining to terminal area operations**
  - **Partner with Airspace Program and in-house modeling of business case costs/ revenue associated with implementing/operating N+2 configurations**
- **Benefit(s)**
  - **Better understanding of the true costs and benefits derived from improved operations for N+2 advanced configurations**

Advanced Vehicle Concepts – Technical Overview

Noise Reduction | Energy Efficiency

4.4.2 Advanced Vehicle Concepts Development for N+2

Airbus
Aviation Week 1/15/01

- **Objective**
  - **Identify robust set of advanced concepts and technologies that enable goals**
  - **Develop technology roadmaps required to meet goals**
  - **Develop in-house system analysis capabilities to independently assess concepts and establish benefit**
- **Approach**
  - **Conduct in house studies of advanced concepts to quantify vehicle system and ATS benefits**
    - High wing, open rotor, over wing nacelle, hybrid wing body, etc.
  - **Utilize the NRA to develop advanced vehicle concept studies with industry**
- **Benefit(s)**
  - **Broaden the set of possible solutions and design trade space**

Advanced Vehicle Concepts – Technical Overview

Noise Reduction | Energy Efficiency

4.4.3 N+2 Advanced Vehicle Concepts NRA

- Scope
  - **N+2 Advanced Concepts/Technologies to simultaneously achieve goals**
  - **Anticipate 3 multi-organizational teams @ $3M per team, 12-18 months**
- Task 1 - develop vehicle concept and detailed system study
  - **Configuration and Engine architecture, id high pay-off target mission (RJ, single aisle, twin aisle, large)**
  - **System analysis for goal assessment vs advanced conventional configuration**
  - **Evaluate extensibility of concept and technologies to broad range of missions (payload, range, speed)**
- Task 2 - develop technology roadmaps + key system research experiments
  - **a) vehicle system, b) airframe system, c) propulsion system**
  - **scale, technology, cost, schedule trades for range of experiments**
- Outcome
  - **New and/or refined ideas emerge**
  - **Detailed information for prioritization of concepts and technologies**
  - **Detailed information for prioritization and selection of future system level research experiments**

Note: A Pre-decisional bidder's conference will occur prior to release

Advanced Vehicle Concepts - Milestones/Resources/Partnerships

Noise Reduction | Energy Efficiency

Milestones

Feb 2010 N+2 Advanced Concept NRA Bidders Conf

Feb 2010 Low-wing, high-wing, Over Wing Nacelle config assm't for UHB

April 2010 N+2 NRA Awarded

Dec 2011 N+2 NRA Adv. Concept Studies Complete, Adv. Vehicle Ops Workshop

Partnerships

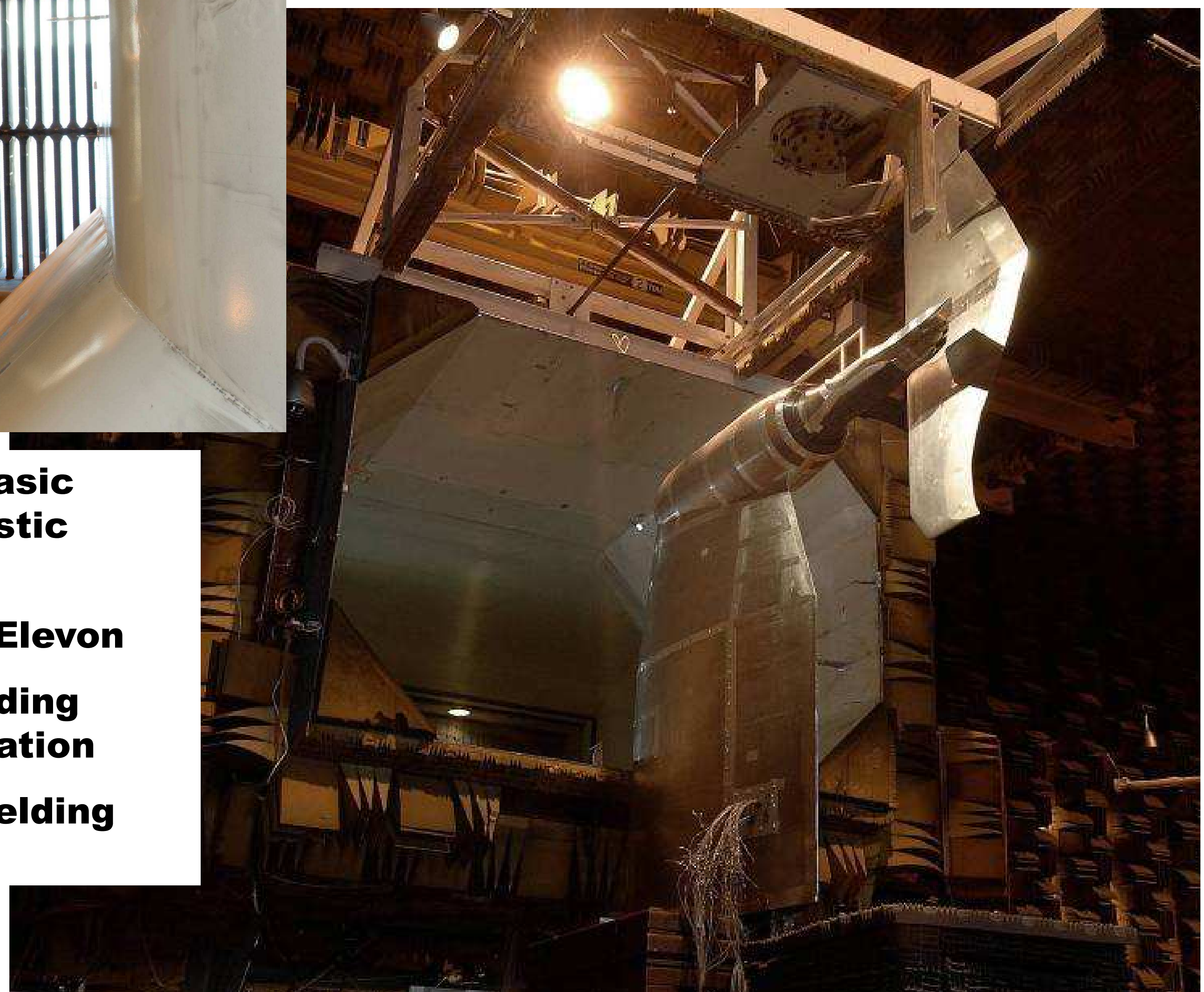
SAA P&W UHB Integration Configuration Assm't

NRA N+2

Backup Charts

2009 Boeing/NASA LSAF Propulsion Airframe Aeroacoustic BWB Experiment – High Quality Data for 2009 Assessment

Ref: Czech, Thomas, and Elkoby, “Propulsion Airframe Aeroacoustics LSAF Experiment Overview,” September 29, 2009, NASA Fundamental Aeronautics Program Annual Meeting

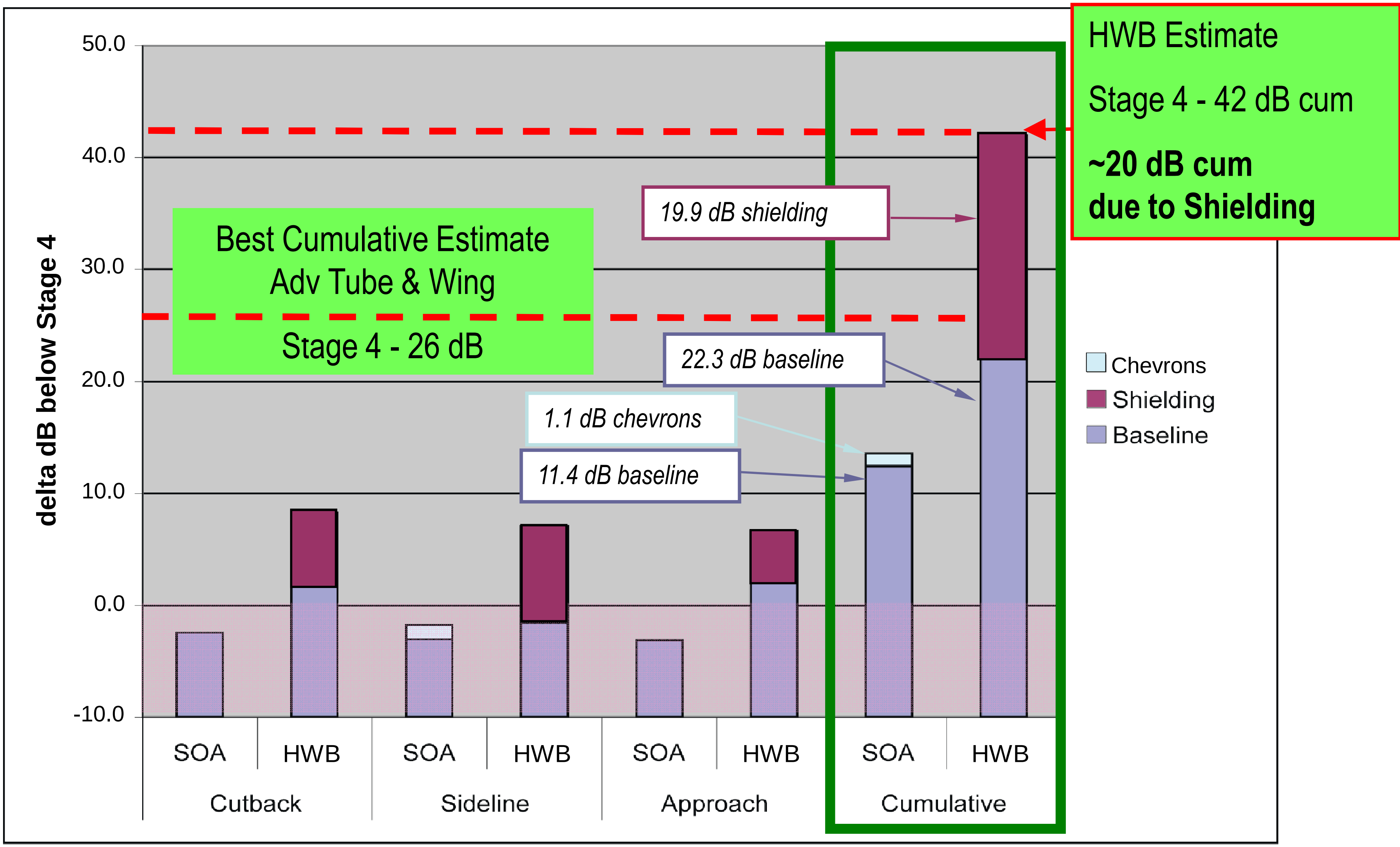


BWB Experiment Improves Basic Understanding of Aeroacoustic Sources and Parameters:

- **Airframe Sources: Slat and Elevon**
- **Jet-Airframe shielding including spacing and source modification**
- **Broadband point source shielding with flow effect**

N+2 Potential Noise Reduction

Includes estimate of maximum propulsion noise shielding



Thomas, Berton, et al